Preface

The art of energy conversion of biomass is as old as our natural habitat. Such processes have been at work since the early days of vegetation on this planet. Flame leaping from forest fire is an example of “flaming pyrolysis.” Trace of blue flame in a swamp is an example of methane gas formation through decomposition of biomass and its subsequent combustion in contact with air. Burning vegetation on ground to increase soil fertility is an example of biochar production. Human beings, however, learned to harness these processes much later.

Use of biomass for energy, though nearly as ancient as human civilization, did not rise at the same pace with industrialization because of the abundant supply and low prices of oil and natural gas. Only in the recent past has there been an upsurge in interest in biomass energy conversion, fueled by several factors:

- Interest in the reduction in greenhouse gas emissions as a result of energy production
- Push for independence from the less reliable supply and fluctuating prices of oil and gas
- Interest in renewable and locally available energy sources
- Rise in the price of oil and natural gas.

Several excellent books on coal gasification are available, but a limited few are available about biomass gasification and pyrolysis, and none on torrefaction. A large body of peer-reviewed literature on biomass gasification, pyrolysis, and torrefaction is available; some recent books on energy also include brief discussions on these topics. For example the previous edition (Biomass Gasification and Pyrolysis) of this book along with its Chinese and Italian versions presents a good treatment of these topics. There is yet a dearth of comprehensive publications specifically on torrefaction. For this reason, the previous book was revised and expanded with several new chapters on such new topics to develop the monograph.

Engineers, scientists, and operating personnel of biomass gasification, pyrolysis, or torrefaction plants clearly need such information from a single easy-to-access source. Better comprehension of the basics of biomass conversion could help an operator understand the workings of such plants, a design engineer to size the conversion reactors, and a planner to evaluate different conversion options. The present book was written to fill this important need. It attempts to mold available research results in an easy-to-use design methodology whenever possible. Additionally, it brings into focus new advanced processes such as supercritical water gasification and torrefaction of biomass.

This book comprises 13 chapters and a number of appendices, which include several tables that could be useful for the design of biomass conversion units and their components. Chapter 1 introduces readers to the art of different forms of biomass energy conversion and its present state of art. It also discusses the motivations for such conversion in the context of current energy scenario around the world. A brief introduction to economic issues around biomass utilization is available in Chapter 2. The properties of biomass, especially those relevant to gasification, torrefaction, and pyrolysis of biomass are included in Chapter 3. Chapter 4 discusses the principles of torrefaction and its recent developments. It also includes a simple method for design of a torrefaction plant. The basics of pyrolysis are included in Chapter 5 that discusses in some details on biochar, a new option for carbon sequestration and soil remediation.

Chapter 6 deals with an important practical problem of biomass gasification—the tar issue. This chapter provides information on the limits of tar content in product gas for specific applications. Chapter 7 concerns the basics of the gasification of biomass. It explains the gasification process and important chemical reactions that guide pyrolysis and gasification. Chapter 8 discusses design methodologies for gasifiers and presents some worked-out examples on design problems. Chapter 9 hydrothermal gasification of biomass, with specific reference to gasification in supercritical water. In recent past, there is much interest in partial substitution of coal with greenhouse gas (GHG) neutral biomass in existing coal-fired power plant. This near term cost effective means for reduction in GHG from coal-fired plants is presented in Chapter 10 that discusses the basics and different aspects of this new option of biomass energy conversion.

The production of chemicals and synthetic fuels is gaining importance, so Chapter 11 provides a brief outline of how some important chemicals and fuels are produced from biomass through gasification. Production of diesel and bio-gasoline along with Fischer–Tropsch synthesis process are also discussed briefly here. One of the common, but often neglected, problems in the design of biomass plant is the handling of biomass. Chapter 12 discusses issues related to this and provides guidelines for the design and selection of handling and feeding equipment. Chapter 13 presents a brief discussion of some commonly used analytical techniques for measurement of important properties of biomass that are essential for design of a biomass energy conversion system. Appendix A contains definitions of biomass, Appendix B lists physical constants and conversion units, and Appendix C includes several tables containing design data. Glossary presents definitions of some terms used commonly in the chemical and gasification industries.